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PHYS 262 HW 2

3.3 $\nu = 20 \qquad T = \nu \pm \sqrt{\nu}$

$T = 20 \pm \sqrt{20}$

$\boxed{T = 20 \pm 4.5}$

This is not a range that we can say is a high rate, it lies within the range of the 16 calculated cases.

3.5

a.) $(5 \pm 1) + (8 \pm 2) - (10 \pm 4)$

3 ± 7 $\qquad \boxed{3 \pm 7}$

b.) $\underset{x}{(5 \pm 1)} \times \underset{y}{(8 \pm 2)}$

$\frac{\delta x}{|x|} = \frac{1}{5} \qquad \frac{\delta y}{|y|} = \frac{2}{8} = \frac{1}{4}$

$\frac{\delta z}{|z|} = \frac{1}{5} + \frac{1}{4} = \frac{4}{20} + \frac{5}{20} = \frac{9}{20} = 45\%$ $\qquad \boxed{40 \pm 18}$

$(5 \cdot 8) \pm 45\%$
$40 \pm 45\%$
40 ± 18

c.) $\underset{x}{(10 \pm 1)} / \underset{y}{(20 \pm 2)}$ $\qquad \boxed{0.5 \pm 0.1}$

$\frac{\delta x}{|x|} = \frac{1}{10} \qquad \frac{\delta y}{|y|} = \frac{1}{10}$

$\frac{\delta z}{|z|} = \frac{1}{10} + \frac{1}{10} = \frac{1}{5} = 20\%$

$(10/20) \pm 20\%$
$\frac{1}{2} + 20\%$
0.5 ± 0.1

d.) $\underset{w}{(30 \pm 1)} \times \underset{x}{(50 \pm 1)} / \underset{y}{(5.0 \pm 0.1)}$ $\qquad \underset{x}{(1500 \pm 80)} / \underset{y}{(5.0 \pm 0.1)}$

$\frac{\delta w}{|w|} = \frac{1}{30} \qquad \frac{\delta x}{|x|} = \frac{1}{50}$ $\qquad \frac{\delta x}{|x|} = \frac{80}{1500} \qquad \frac{\delta y}{|y|} = \frac{0.1}{5.0}$ $\qquad \boxed{3.0 \times 10^2 \pm 20}$

$\frac{\delta z}{|z|} = \frac{1}{30} + \frac{1}{50} = \frac{4}{75}\%$ $\qquad \frac{\delta z}{|z|} = \frac{80}{1500} + \frac{0.1}{5.0} = 7.3\%$

$(30 \cdot 50) \pm 5.3\%$ $\qquad (1500 / 5.0) \pm 7.3\%$
$1500 \pm 5.3\%$ $\qquad 300 \pm 7.3\%$
1500 ± 80 $\qquad 300 \pm 22$

3.14

$d = \frac{1}{2}gt^2 \quad t = 3.0 \pm 0.5\,(s) \quad g = 9.80\ m/s^2$

$$\frac{\delta t}{|t|} = \frac{0.5}{3.0} = \frac{1}{6} = 16.6\% \qquad \frac{\delta g}{|g|} = \frac{0}{9.8} = 0$$

because t is squared in the equation, its uncertainty is twice as high, $\frac{1}{3}$

So, $d = \frac{1}{2}gt^2$: $d = 0.5\,(9.80\,m/s^2)(3.0\,s)^2 \pm 33.3\%$

$= 44.1 \pm 33.3\%$

$= 44.1 \pm 14.7\ m$

$\boxed{d = 44 \pm 15\ m}$

3.19

a.) $(5 \pm 1) + (8 \pm 2) - (10 \pm 4)$

$$\delta q = \sqrt{(\delta x)^2 + (\delta y)^2 + (\delta z)^2}$$
$$= \sqrt{(1)^2 + (2)^2 + (4)^2} = 4.58$$

$5 + 8 - 10 = 3$ $\quad \boxed{3 \pm 5}$

b.) $(5 \pm 1) \times (8 \pm 2)$

$$\delta q = \sqrt{\left(\frac{\delta x}{|x|}\right)^2 + \left(\frac{\delta y}{|y|}\right)^2}$$
$$= \sqrt{\left(\frac{1}{5}\right)^2 + \left(\frac{1}{4}\right)^2}$$

$\delta q = 32\%$

$40 \pm 32\%$

40 ± 13 $\quad \boxed{40 \pm 13}$

c.) $(10 \pm 1) / (20 \pm 2)$

$$\delta q = \sqrt{\left(\frac{1}{10}\right)^2 + \left(\frac{2}{20}\right)^2} = 14\%$$

$\frac{1}{2} \pm 14\%$

0.5 ± 0.07 $\quad \boxed{0.50 \pm 0.07}$

d.) $(30 \pm 1) \times (50 \pm 1) / (5.0 \pm 0.1)$

$$\delta q = \sqrt{\left(\frac{\delta x}{|x|}\right)^2 + \left(\frac{\delta y}{|y|}\right)^2}$$
$$= \sqrt{\left(\frac{1}{30}\right)^2 + \left(\frac{1}{50}\right)^2}$$

$= 3.8\%$

$1500 \pm 3.8\%$

(1500 ± 58)

$(1500 \pm 58) / (5.0 \pm 0.1)$

$$\delta q = \sqrt{\left(\frac{\delta x}{|x|}\right)^2 + \left(\frac{\delta y}{|y|}\right)^2}$$
$$= \sqrt{\left(\frac{58}{1500}\right)^2 + \left(\frac{0.1}{5.0}\right)^2}$$

$\delta q = 4.3\%$

$300 \pm 4.3\%$

300 ± 13

$\boxed{3.0 \times 10^2 \pm 13}$

#	Straight Sum	Quadratic Sum
a	3 ± 7	3 ± 5
b	40 ± 18	40 ± 13
c	0.5 ± 0.1	0.50 ± 0.07
d	$3.0 \times 10^2 \pm 20$	$3.0 \times 10^2 \pm 13$

3.28

$T = 2\pi\sqrt{L/g}$ $\qquad L = 1.40 \pm 0.01\, m$

a.) $\frac{\delta l}{|l|} = \frac{0.01}{1.40} = 0.7\%$

$T = 2\pi\sqrt{\frac{1.40\, m}{9.80\, m/s^2}} \pm 0.35\%$

$T = 2\pi\sqrt{\frac{1.40m}{9.80\, m/s^2}} \pm 0.01$

$T = 2.37 \pm 0.00848$

$\frac{dT}{dL} = 2\pi\sqrt{\frac{L}{g}}$ $\qquad (L/g)^{1/2}$ $\qquad \frac{1}{2}(L/g)^{-1/2} \cdot 1/g$

$\frac{dT}{dL} = \frac{\pi}{\sqrt{L/g} \cdot g}$ $\qquad \frac{dT}{dL} \cdot \delta L$

$\frac{dT}{dL} = \frac{\pi}{\sqrt{\frac{1.4m}{9.8m/s^2}} \cdot 9.8\, m/s^2} = 0.84815 \cdot 0.01 \cong 0.0085$

$\boxed{T = 2.3748 \pm 0.0085\,(s)}$

b.) The measured value of $T = 2.39 \pm 0.01S$ is consistent with the theoretical prediction. The tolerance of the two will overlap.

3.42

a.) $a = \frac{V_2^2 - V_1^2}{2s} = \left(\frac{l^2}{2s}\right)\left(\frac{1}{t_2^2} - \frac{1}{t_1^2}\right)$ $\qquad \theta = 5.4 \pm 0.1$

$\delta a = \sqrt{(0.1)^2} = 0.1$

$a = g\sin\theta = (9.8\, m/s^2)\sin(5.4) \pm 0.1$

$= (0.922261\, m/s^2) \pm 0.1$

$\boxed{a = 0.9 \pm 0.1\, m/s^2}$

b.) $t_1 = 0.038$ $\qquad t_2 = 0.027$ $\qquad l = 5.00 \pm 0.05\, cm$ $\qquad s = 100.0 \pm 0.2\, cm$

i.) $\frac{\delta t_1}{|t_1|} = \frac{0.001}{0.038} \times 100 = 2.6\% \approx 3\%$ $\qquad \frac{\delta l}{|l|} = \frac{0.05}{5.00} \times 100 = 1\%$ $\qquad t_1 = 3\% \therefore \frac{1}{t_1^2} = 6\%$

$\frac{\delta t_2}{|t_2|} = \frac{0.001}{0.027} \times 100 = 3.7\% \approx 4\%$ $\qquad \frac{\delta s}{|s|} = \frac{0.2}{100} \times 100 = 0.2\%$ $\qquad t_2 = 4\% \therefore \frac{1}{t_2^2} = 8\%$

$t_1 = 0.038 \pm 3\%$
$t_2 = 0.027 \pm 4\%$

$\frac{\delta g\left(\frac{l^2}{2s}\right)}{\left|\frac{l^2}{2s}\right|} = \sqrt{\left(2\frac{\delta l}{l}\right)^2 + \left(\frac{\delta s}{s}\right)^2} = \sqrt{(2 \cdot 1)^2 + (0.2)^2} = 2\%$ $\qquad \frac{l^2}{2s} = \frac{5^2}{2(100)} \pm 2\% = 0.125 \pm 0.0025\, cm$
$= 0.125 \pm 2\%$

$\frac{1}{t_1^2} = \frac{1}{(0.038)^2} \pm 6\% = 693 \pm 6\%$
$= 693 \pm 42$

$\frac{1}{t_2^2} = \frac{1}{(0.027)^2} \pm 8\% = 1372 \pm 8\%$
$= 1372 \pm 110$

$\frac{1}{t_2^2} - \frac{1}{t_1^2} = \sqrt{(\delta t_2^2)^2 + (\delta t_1^2)^2} = \sqrt{(110)^2 + (42)^2} = 118 \quad : \quad \frac{1}{t_2^2} - \frac{1}{t_1^2} = (1372 \pm 110) - (693 \pm 42) = 678 \pm 118$
$= 678 \pm \left(\frac{118}{678}\right) \times 100$

$$\frac{\delta a}{|a|} = \sqrt{\left(\frac{\delta\left(\frac{l^2}{2s}\right)}{\frac{l^2}{2s}}\right)^2 + \left(\delta\left(\frac{1}{t_2^2} - \frac{1}{t_1^2}\right)\right)^2} = \sqrt{(2)^2 + (17)^2} = 17.11 \approx 17\%$$

$= 678 \pm 17\%$
$\boxed{= 678 \pm 115}$

$$a = \left(\frac{l^2}{2s}\right)\left(\frac{1}{t_2^2} - \frac{1}{t_1^2}\right) \pm \frac{\delta a}{|a|}$$

$$= \frac{5^2}{2(100)}\left(\frac{1}{(0.027)^2} - \frac{1}{(0.038)^2}\right) \pm 17\%$$

$= 85 \pm 17\%$
$\boxed{a = 85 \pm 14 \ cm/s^2}$

ii.) $t_1 = 0.025 \ (s)$ $t_2 = 0.020 \ (s)$ $l = 5.00 \pm 0.05 \ cm$ $s = 100.0 \pm 0.2 \ cm$

$$\frac{\delta t_1}{|t_1|} = \frac{0.001}{0.025} \times 100 = 4\% \qquad \frac{\delta t_2}{|t_2|} = \frac{0.001}{0.020} \times (100) = 5\% \qquad \frac{\delta l}{|l|} = 1\% \qquad \frac{\delta s}{|s|} = 0.2\%$$

$\boxed{t_1 = 0.025 \pm 4\%}$
$\boxed{t_2 = 0.020 \pm 5\%}$

$$\frac{\delta\left(\frac{l^2}{2s}\right)}{\left|\frac{l^2}{2s}\right|} = \sqrt{\left(2\frac{\delta l}{|l|}\right)^2 + \left(\frac{\delta s}{|s|}\right)^2} = \sqrt{(2.1)^2 + (0.2)^2} = 2\%$$

$$\frac{5^2}{2(100)} \times 2\% = 0.125 \pm 2\%$$
$$= 0.125 \pm 0.0025 \ cm$$

$$\frac{1}{t_1^2} = \frac{1}{(0.025)^2} \pm 8\% = 1600 \pm 8\%$$
$\boxed{= 1600 \pm 128}$

$$\frac{1}{t_2^2} = \frac{1}{(0.020)^2} \pm 10\% = 2500 \pm 10\%$$
$\boxed{= 2500 \pm 250}$

$$\frac{1}{t_2^2} - \frac{1}{t_1^2} = \sqrt{(\delta t_2^2) + (\delta t_1^2)} = \sqrt{250^2 + 128^2} = 280$$

$$\frac{1}{t_2^2} - \frac{1}{t_1^2} = (2500 \pm 250) - (1600 \pm 128) = 900 \pm \left(\frac{280}{900}\right) \times 100$$

$= 900 \pm 31\%$
$\boxed{= 900 \pm 279}$

$$\frac{\delta a}{|a|} = \sqrt{\left(\frac{\delta\left(\frac{l^2}{2s}\right)}{\left|\frac{l^2}{2s}\right|}\right)^2 + \left(\delta\left(\frac{1}{t_2^2} - \frac{1}{t_1^2}\right)\right)^2} = \sqrt{(2)^2 + (31)^2} = 31\%$$

$$a = \left(\frac{l^2}{2s}\right)\left(\frac{1}{t_2^2} - \frac{1}{t_1^2}\right) \pm 31\%$$

$$a = \left(\frac{5^2}{2(100)}\right)\left(\frac{1}{0.02^2} - \frac{1}{0.025^2}\right) \pm 31\%$$

$= 113 \pm 31\%$
$a = \boxed{113 \pm 35 \ cm/s^2}$

$t_1 (s)$ ± 0.001	$t_2 (s)$ ± 0.001	$1/t_1^2$	$1/t_2^2$	$1/t_1^2 - 1/t_2^2$	a (cm/s^2)
$0.054 \pm 2\%$	$0.031 \pm 3\%$	343 ± 14	1040 ± 62	698 ± 64	87 ± 8
$0.038 \pm 3\%$	$0.027 \pm 4\%$	693 ± 42	1372 ± 110	678 ± 115	85 ± 14
$0.025 \pm 4\%$	$0.020 \pm 5\%$	1600 ± 128	2500 ± 250	900 ± 279	110 ± 40

The results from the table are consistent with what was found in part a. Pushing the cart harder for the constancy of a at higher speeds would be a good idea because this would allow for more data in the experiment and a wider range of speeds to test the theory on.

7)

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} \qquad R_1 = 220\,\Omega \pm 5\% \qquad R_1 = 220\,\Omega \pm 11$$
$$R_2 = 100\,\Omega \pm 8\% \qquad R_2 = 100\,\Omega \pm 8$$

a.) Rearrange to solve for R_{eff},

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} \quad : \quad R_{eff} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} \quad : \quad R_{eff} = \left(\frac{R_1+R_2}{R_1 R_2}\right)^{-1} \qquad R_{eff} = \frac{R_1 R_2}{R_1+R_2}$$

$$\boxed{R_{eff} = \frac{R_1 R_2}{R_1+R_2}}$$

$$\delta R_{eff} = \sqrt{\left(\frac{dR_e}{dR_1}\delta R_1\right)^2 + \left(\frac{dR_e}{dR_2}\delta R_2\right)^2}$$

b.) $$\frac{dR_e}{dR_1} : \frac{(R_1+R_2)(R_2) - (R_1)(R_2)(1)}{(R_1+R_2)^2} = \frac{R_2\left((R_1+R_2) - (R_1)\right)}{(R_1+R_2)^2} = \left(\frac{R_2^2}{(R_1+R_2)^2}\right) = \left(\frac{100\,\Omega^2}{(220\,\Omega+100\,\Omega)^2}\right) = \frac{25}{256}$$

$$\frac{dR_e}{dR_2} : \frac{(R_1+R_2)(R_1) - (R_1)(R_2)(1)}{(R_1+R_2)^2} = \frac{R_1\left((R_1+R_2) - R_2\right)}{(R_1+R_2)^2} = \left(\frac{R_1^2}{(R_1+R_2)^2}\right) = \left(\frac{220\,\Omega^2}{(220\,\Omega+100\,\Omega)^2}\right) = \frac{121}{256}$$

$$\delta R_e = \sqrt{\left(\frac{25}{256}\cdot 11\right)^2 + \left(\frac{121}{256}\cdot 8\right)^2} = 3.93 \approx 4.0$$

$$R_{ef} = \frac{R_1 R_2}{R_1+R_2} = \frac{(220\,\Omega)(100\,\Omega)}{220\,\Omega + 100\,\Omega} = 68.75 \approx 69$$

$$\boxed{R_{ef} = 69 \pm 4\,\Omega}$$